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H4K
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(54) Testing telephone lines

(57) An automatic remote line testing device at subscribers premises enables a telephone line to be tested from the exchange when the subscriber has equipment connected to the other end, even when the equipment is providing a short or open circuit. The device comprises a command tone validating circuit (3), command tone and test signal interface circuits (2) and line transformer and power extractor circuits (1).

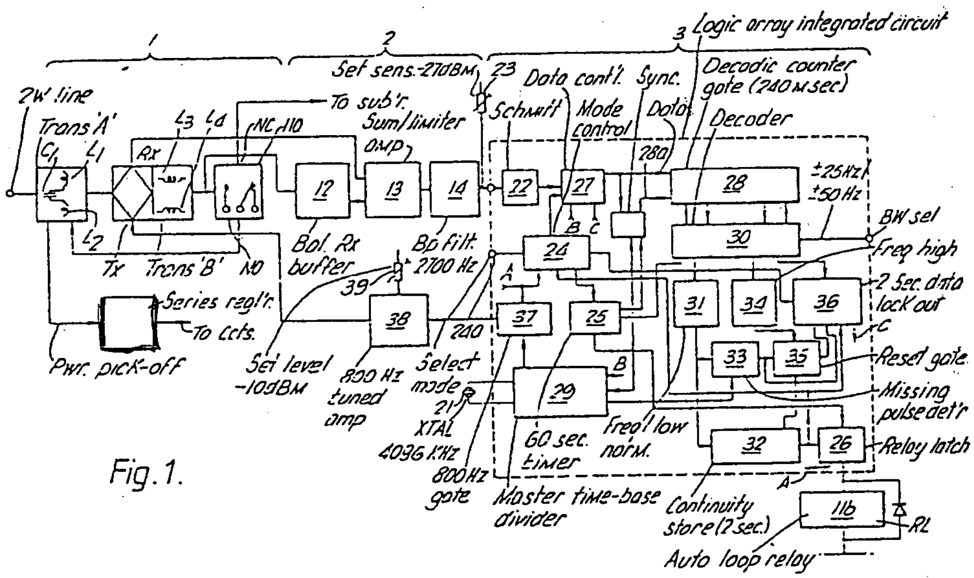

Fig. 1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 176 970 A

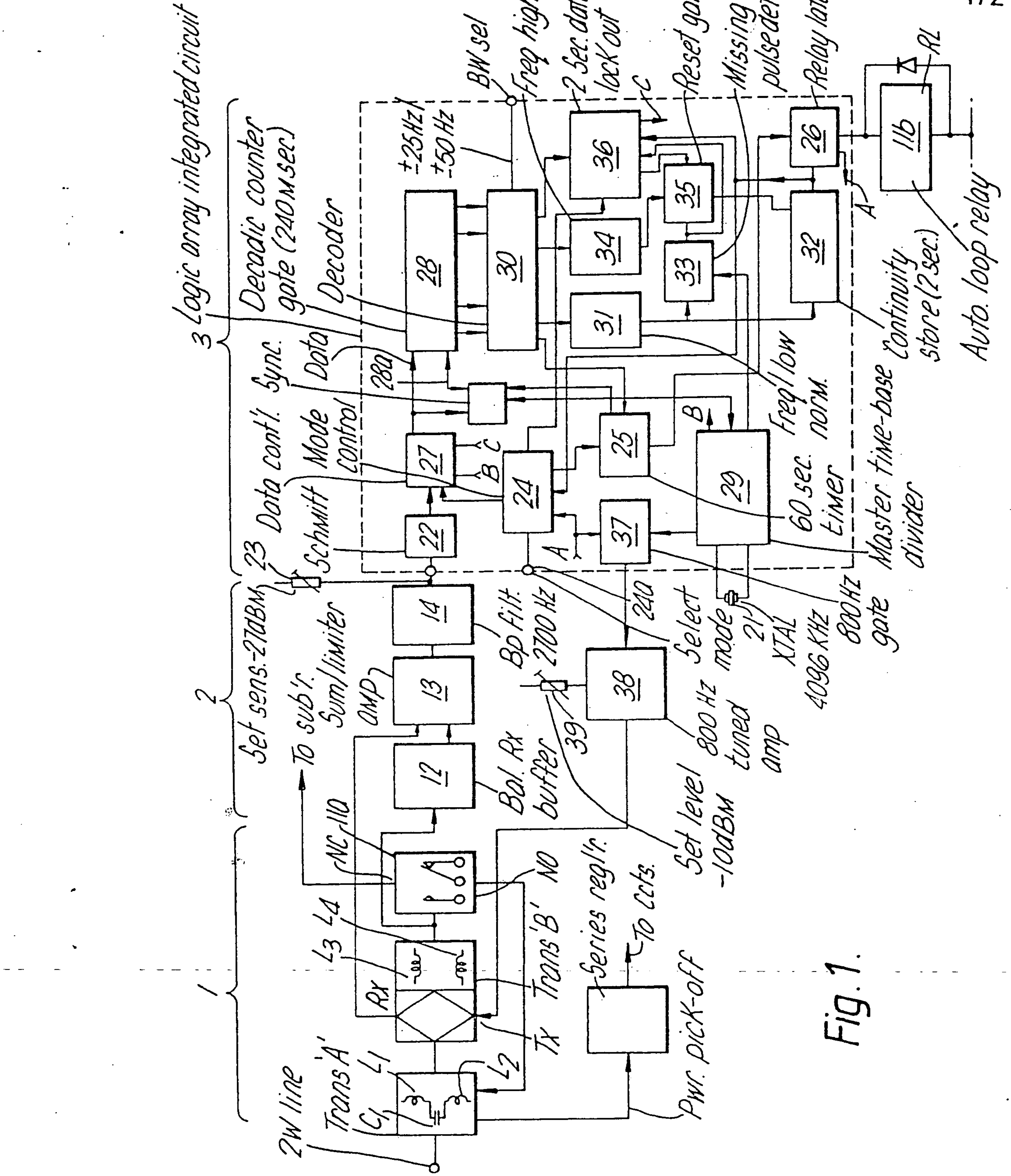
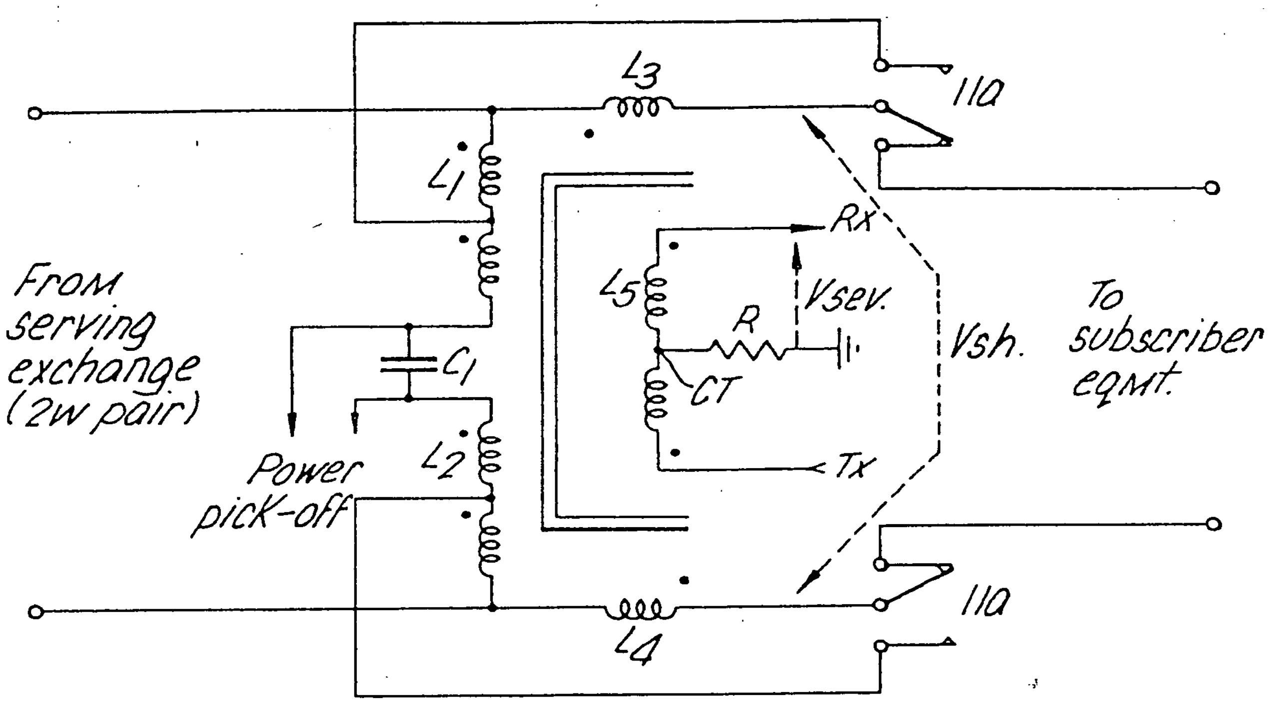

2W line
Trans 'A'
C_1
L_1
L_2
Rx
Tx
L_3
L_4
Trans 'B'
NC 110
NO
To sub'r.
Series reg'r.
To ccts.
Pwr. pick-off
12
13
14
Bal. Rx buffer
Sum/limiter amp
Bp filt. 2700 Hz
Set sens. -27dBM
23
38
39
Set level -10dBM
800 Hz tuned amp
240
Select mode
21
XTAL 4096 KHz
800 Hz gate
22
27
24
25
37
29
Schmitt
Data cont'l.
Mode control
Sync.
Data
28a
B
C
A
60 sec. timer
Master time-base divider
Freq/low norm.
28
30
31
34
36
35
33
32
26
116
RL
Decadic counter gate (240 M sec)
Decoder
Logic array integrated circuit
÷25 Hz
÷50 Hz
BW sel
Freq high
2 Sec. data lock out
Reset gate
Missing pulse det'r
Relay latch
Continuity store (2 sec.)
Auto. loop relay
1
2
3

Fig. 1.

Fig. 2.


L3
11a
L1
Rx
L5
Vsev.
R
From
serving
exchange
(2w pair)
CT
Vsh.
To
subscriber
eqmt.
C1
Power
pick-off
L2
Tx
11a
L4

SPECIFICATION

Testing telephone lines

This invention relates to testing telephone lines, and to a device responsive automatically to a test tone received from the remote line end for validating the tone and responding thereto.

It is useful to be able to test a telephone line remotely from a telephone exchange in response to e.g. a subscriber complaint, before despatching an engineer to check the line or the subscriber equipment. With the increase in the amount of equipment being connected to a telephone line at the subscriber's premises, there is clearly going to be an increase in the number of faults reported, and many of these may be due to the subscriber's equipment. If this is not purchased or leased from the telephone operating company such as British Telecom in the UK, then the operating company will only need to ensure the leased telephone line is functioning normally and to distinguish between a faulty line on the one hand, and faulty equipment on the other hand for which the operating company may not be responsible.

Our co-pending application 8330055 describes an automatic line tester which is highly immune to misoperation.

It is an object of the present invention to enable such a remote line testing device to operate on a 2-wire system such as generally used in the Public Switched Telephone Network in the United Kingdom, and provides means for powering such a device.

According to the present invention there is provided a transponder for connection to a 2-wire telephone line at a subscriber's premises and which can be interrogated remotely from e.g. the exchange to test the line, by returning a test signal in response to the interrogation signal, the transponder comprising a line transformer having a split winding from which power is picked off for powering the transponder from the line whilst remaining transparent to the subscriber connection, a receive circuit for selecting the interrogation signal, and protocol logic for determining the validity of the interrogation signal and sending the test signal in response to a valid finding.

Preferably the transponder comprising a tone filter for shaping the test signal and means for generating the test signal.

Preferably the transponder comprising a line relay operable by the protocol logic to disconnect the subscriber from the line during sending of the test signal.

Preferably the transformer has a split primary winding providing power pick off, and a secondary winding having a transmit portion for feeding the test signal to the line in response to interrogation and a receive portion for receiving the interrogation signal.

In order that the invention can be clearly understood reference will now be made to the accompanying drawing in which

Figure 1 is a block diagram of a remote line tester transponder according to an embodiment of the invention, and

Figure 2 shows detail of the line transformer of Figure 1.

The remote line tester responds to a command, presently a signal tone, sent from the exchange having a preset frequency and a preset minimum duration and the tester recognises this signal and only this signal to provide a confirmation tone e.g. 800Hz back on the pair of telephone wires. It must not of course interfere with the normal usage of the line.

Referring to Figure 1 of the drawings, the tester comprises three sections, namely the line transformer and power extraction circuits 1, the command tone and test signal interface circuits 2 and the command tone processor 3 which in this embodiment is realised in integrated circuit form.

The line transformer and thereby the power extraction circuits 1 are connected to the 2-wire line (2W Line) from the Exchange. Part of the line transformer TRANS-A comprises primary winding, L_1 and L_2 and coupling capacitor C_1 for providing DC separation and AC coupling between the primary windings L_1, L_2.

DC from the exchange is applied to a series regulator SR which provides regulated DC to the various circuit components of the transponder.

In series with the line are automatic disconnect relay contacts 11a, and the second part of the transformer TRANS-B incorporating series windings L_3, L_4 and a centre-tapped hybrid winding L_5. The series windings L_3, L_4 permit d.c. to be fed to the subscriber's equipment with normal line signals, and are also used to couple the interrogation signal to the hybrid winding L_5 and thence to the sum/limiter amplifier 13 where the line will have either a termination or a short circuit (e.g. malfunction).

The balanced detector 12, connected transversely across windings L_3 and L_4 will "see" a degree of voltage dependent upon the level of termination, its output also being fed to the sum/limiter amplifier 13, to complement the "current" induced signal obtained from L_3 and L_4.

Under any of these conditions the interrogation from the exchange will cause the test tone to be returned to the exchange while the subscriber's equipment is automatically disconnected for the period of the test (in one option of this embodiment 60 secs.).

Figure 2 shows in further details the line transformer with power pick off and connections for the loop back relay contacts. In particular it shows the phasing of the windings, L_1, L_2, L_3, L_4, L_5. Further there is shown the relay contact sets 11a which, during normal use of the subscriber's telephone circuit provide a direct connection for the 2-wire pair. Also in this condition, the shunt inductance of the whole of windings L_1 and L_2 in series is maintained, thus presenting a high impedance transversely to the subscriber's circuit.

When the relay winding 11b is energised the contact sets change over to parallel L_3 with a portion of L_1, and similarly L_4 with L_2, to now present the correct source/terminating impedance to the circuit. The subscriber is disconnected for the duration of the test. The hybrid windings L_5 are effectively divided into a transmit portion Tx, for transmitting the test tone, and a receive portion Rx for receiving the interrogation signal, by a centre tap CT to earth via a resistor R, in this embodiment 300 ohms. When the line is being

interrogated, the system is timed, requiring only one command to initiate looping through relay 11, the transponder restoring to the unlooped condition after a finite time has elapsed. During this time an 800 Hz tone is emitted via the transmit Tx hybrid winding L_5.

The automatic loop circuit is provided by reed relay contacts 11a driven from the decoded command tone of 2700 Hz transmitted from the serving exchange via the line.

In a further option of this embodiment the relay circuit is latched. A subsequent interrogating tone is thus used to release the relay. During the latched state the test tone is maintained, and it is a feature of the hybrid winding L_5 as coupled to the transmit/receive windings L_1 and L_2, in this case, paralleled by L_3 and L_4 respectively to distinguish between the interrogative and test tones and therey release the relay during the transmission of test tone.

The interface circuits 2 in conjunction with the balanced line transformer TRANS together with a balanced input voltage amplifier 12 (input buffer) and summing/limiter amplifier 13 are arranged that irrespectively of whether the customer's apparatus presents:-

(i) its correct terminating impedance,
(ii) an open circuit,
(iii) a short circuit,

then a substantially constant voltage is obtained in the summing amplifier 13. Hence line test operation is ensured under all customer conditions inclusive of a fault.

The interface circuits 2 operate in dependence upon the principles employed in the line transformer. For an understanding of the circuitry consider the voltages/currents in the transformer windings, with reference to Figure 2, during the three customer operation states mentioned above.

(i) For a correct termination a given current flows in the series line windings L_3, L_4 which therefore induces a known voltage V_{ser} in the suitably phased hybrid winding L_5. Also a known voltage V_{sh} appears across the customer termination which is sensed by the differential input buffer 12. The results of these two signal paths are dealt with in the summing amplifier 13 in a fixed ratio. This ratio is so chosen to preserve a given summed voltage.

(ii) For the open circuit case no current flows in the series windings L_3, L_4 and hence no voltage (V_{ser}) is induced in the hybrid winding of the transformer but the load voltage (V_{sh}) of the first case (i) is doubled.

(iii) In the closed circuit case the current in the series windings L_3, L_4 and hence the voltage (V_{ser}) induced in the transformer hybrid winding L_5 is doubled w.r.t. the first case (i) but here there is no voltage (V_{sh}) input in the differential amplifier.

The overall mechanism is such that in the three cases, and equally for all partial terminations, a reasonably constant voltage is derived at the input to the summing amplifier 13, and thereby, independance of any termination.

The summing amplifier 13 is also configured as a limiter to provide approximately constant drive to the processor.

Noise immunity is enhanced by the inclusion of an active bandpass filter 14 centred at 2700 Hz. The signal from the interface circuit 2 is fed to a command tone processor 3. This circuit is realised as a semi-custom integrated device using low power technology. The principle is that of a sampling frequency counter with programmed bounds. The whole process is controlled by a highly stable crystal oscillator 21 with a master frequency of 4096 KHz.

The input frequency of 2700 Hz is applied to a Schmitt trigger 22. The output of the trigger 22 is fed to a data control 27. An external signal, logic low, is preset at the select pin 24a to set up the mode of operation in which both an 800 Hz gate circuit 37 and a 60 second timer circuit 25 are operative.

The input signal is fed via the data control circuit 27 to a decadic counter 28. The gate input 28A to this counter receives a timing signal from a sync circuit SYNC which synchronizes a master time base divider 29. This gates the counter on for a period of 240 msec. and off for a period of 80msec. During the "on" counting phase the input frequency, if correct, will cause the counter to accumulate 648 counts. The decoder 30 which operates in three bit mode is arranged to "look" for predetermined counts above and below 648 representative of a band of frequencies. In this way finely toleranced frequency limits can be set. An external logic signal preset by the user to select the bandwidth (BW-SEL) allows the decoder to operate at any of two pre-fixed bandwidths. Counts representative of ± 25 Hz are selected by logic low and ± 50 Hz by logic high. An "in range" frequency causes the decoder 30 to provide a pulse every 320msec. via the frequency low/normal circuit 31 to both a continuity store 32 and a resettable timer 33, which "looks" for missing pulses.

The continuity store 32 is looking for seven successive pulses within the period 2 to 3 seconds, and in response to that will set the relay latch 26 and send an instruction to the mode control 24 (see connection A).

This institutes the 60sec tone back sequence subject to the appropriate mode select (24a) input being selected. Alternatively the sequence does not employ the 60sec timing but remains latched whilst returning test tone. In this case a subsequent interrogation command is required to release the latch. This in turn requires the removal of the initial interrogation signal, if still present. Its removal initiates the 2 second data lockout sequence, described later.

Out of range frequencies are discriminated against in the following ways:-

(i) Where the frequency is too high then the decoder 30 gives an output via the frequency high circuit 34 to a reset gate 35 which is effective to reset the continuity store 32. Thus this store will not count more than one pulse and the relay latch 26 will not be set.

(ii) Where the frequency is too low, or indeed absent, then the decoder 30 will not provide pulses to the frequency low/normal circuit 31. This in turn will not provide pulses for the timer 33. This circuit, the missing pulse detector, acts as a re-triggerable monostable with a period in excess of 320ms (in this embodiment 420ms). If the timer 33 is not reset it changes state to create, via reset gate 35, a reset of continuity store 32. Thus the absence of a single

count or more is accommodated, thereby ensuring the detection of breaks in transmission of short duration. This provides a high degree of immunity to misoperation.

A further circuit, a two second data lock-out 36 also makes use of the monostable timer 31 properties. When the condition arises that:-

(a) The relay latch 26 has operated and

(b) Interrogation tone has ceased (determined as detection of absence of tone by change of state of the timer 33),

then the two second data lock-out comes into play.

When initiated it acts on the data control 27 via connection C to accept an alternative data source provided by the master time-base 29 via connection B. This is fed to the decadic counter 28 to be decoded by a subsection of the decoder 30. The count, representative of the time span 2 seconds, uses a number smaller than those adopted for bandwidth checking in order not to create any unwanted states in the continuity store 32 or reset activities from the reset gate 35.

The termination of the count sequence re-establishes the data input via the data control 27 and resets the continuity store 32 via the reset gate 35. The cycle of command interrogation may now be repeated to either repeat the latch setting or releasing sequence depending upon selected mode.

The reset circuitry is carefully arranged such that in addition to out of range frequencies not operating the latch 26, the loss of a single count (or more) in the sequence of seven counts gives an invalid total count. For example, a short break or interruption in transmission of the frequency might occur, and this is to be rejected as invalid. This provides a high degree of immunity to misoperation.

In the timed mode from the point of recognition, previously described as the setting of the relay latch and an instruction is passed to the mode control 24, this activates the circuits 25 and 37. The 60 second timer takes input from the time base 29. On reaching count maturity it provides a signal to reset the relay latch 26 thereby releasing the relay coil 11b and the contact set 11a.

From the time that the 60 second counter is started, until termination, the 800 Hz select circuit 37 takes an output from the time-base, as a square wave, and passes it as the test tone from the processor to an 800 Hz tuned amplifier 38 which shapes the test tone to give a reasonably pure sinusoidal tone suited to line transmission. The level of this tone is further set by a potentiometer 39.

The processor is designed so that data guarding occurs i.e. 800 Hz is prevented from reaching the counter.

In the latched mode the instruction to the mode control 24 is inhibited and thus circuit 25 is inoperative. Circuit 37 remains enabled and taken an 800Hz output from the time base for feeding to line as in the timed mode.

The processor can be used not only to operate an auto return signal facility such as loop-back or 800 Hz signal in response to an input frequency of predetermined parameter. The processor could be used to remotely operate some other device where a high degree of immunity to misoperation is important.

The processor 3 can be realised in integrated circuit form as a custom uncommitted logic array.

CLAIMS

1. A transponder for connection to a 2-wire telephone line at a subscriber's premises and which can be interrogated remotely from e.g. the exchange to test the line, by returning a test signal in response to the interrogation signal, the transponder comprising a line transformer having a split winding from which power is picked off for powering the transponder from the line whilst remaining transparent to the subscriber connection, a receive circuit for selecting the interrogation signal, and protocol logic for determining the validity of the interrogation signal and sending the test signal in response to a valid finding.

2. A transponder as claimed in claim 1 and comprising a line relay operable by the protocol logic to disconnect the subscriber from the line during sending of the test signal.

3. A transponder as claimed in claim 1 or 2, wherein the transformer comprises a split shunt primary windings, having high impedance properties and providing power pick off, and a secondary winding having a transmit portion for feeding the test signal to the line in response to interrogation and a receive portion for receiving the interrogation signal.

4. A transponder as claimed in claim 3, comprising line relay contacts disposed between the series winding and the customer connection and arranged to connect the suitably phased series winding across a portion of the split shunt winding to create the required line transmitting/terminating impedance when the customer connection is disconnected and either or both the interrogating and test signals are being received and transmitted respectively.

5. A transponder substantially as hereinbefore described with reference to the accompanying drawings.

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